Jet substructure in pp collisions at $\sqrt{s}$ = 13 TeV

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HARD PROBES 2018

ALICE

OAK RIDGE National Laboratory

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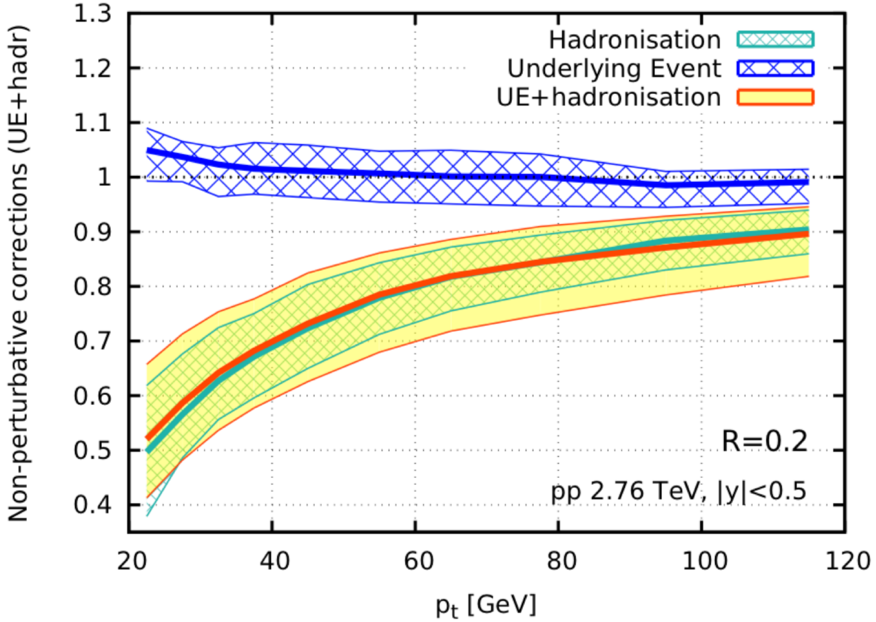
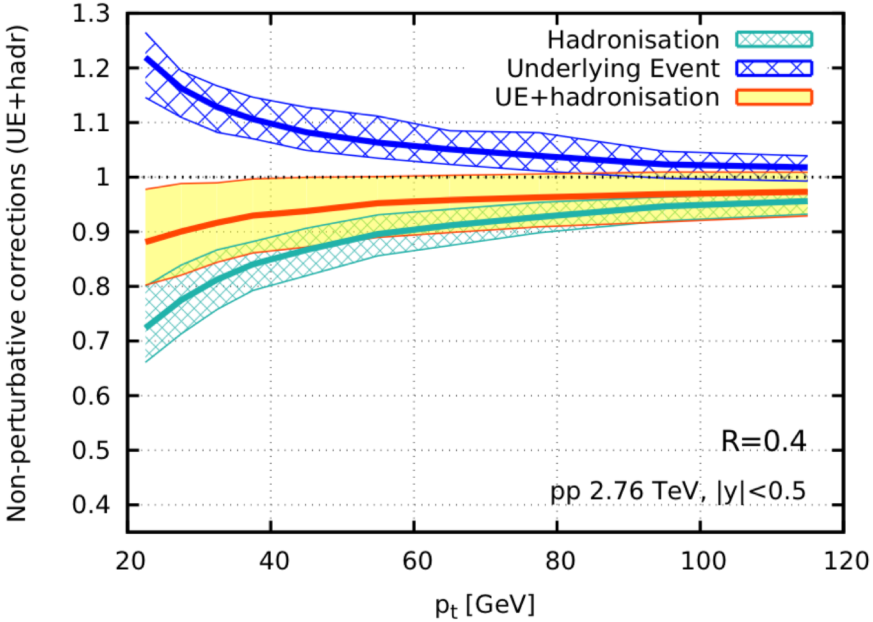
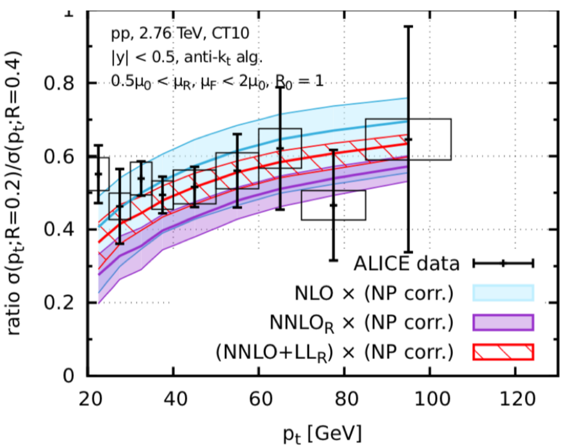
Jet measurements at low p_T

M. Dasgupta,F. Dreyer, G. Salam, G. Soyez JHEP 06 (2016) 057







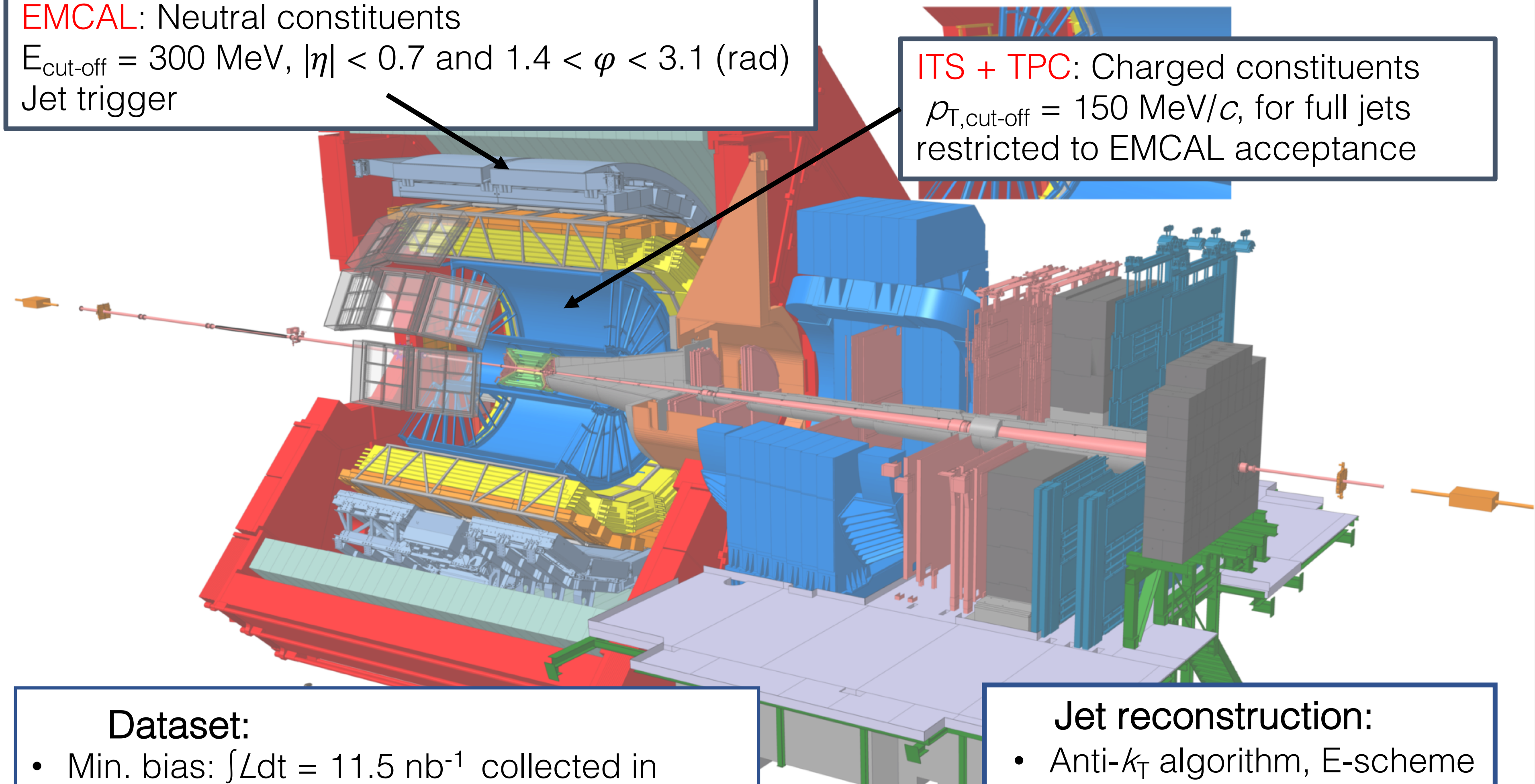
Unique opportunity to constrain perturbative and non-perturbative effects with ALICE

New data allows for more differential studies using jet substructure observables

Jet substructure measurements with ALICE

EMCAL: Neutral constituents
$E_{cut\text{-}off}$ = 300 MeV, $|\eta| < 0.7$ and $1.4 < \varphi < 3.1$ (rad)
Jet trigger

ITS + TPC: Charged constituents
$p_{T,cut\text{-}off}$ = 150 MeV/c, for full jets restricted to EMCAL acceptance

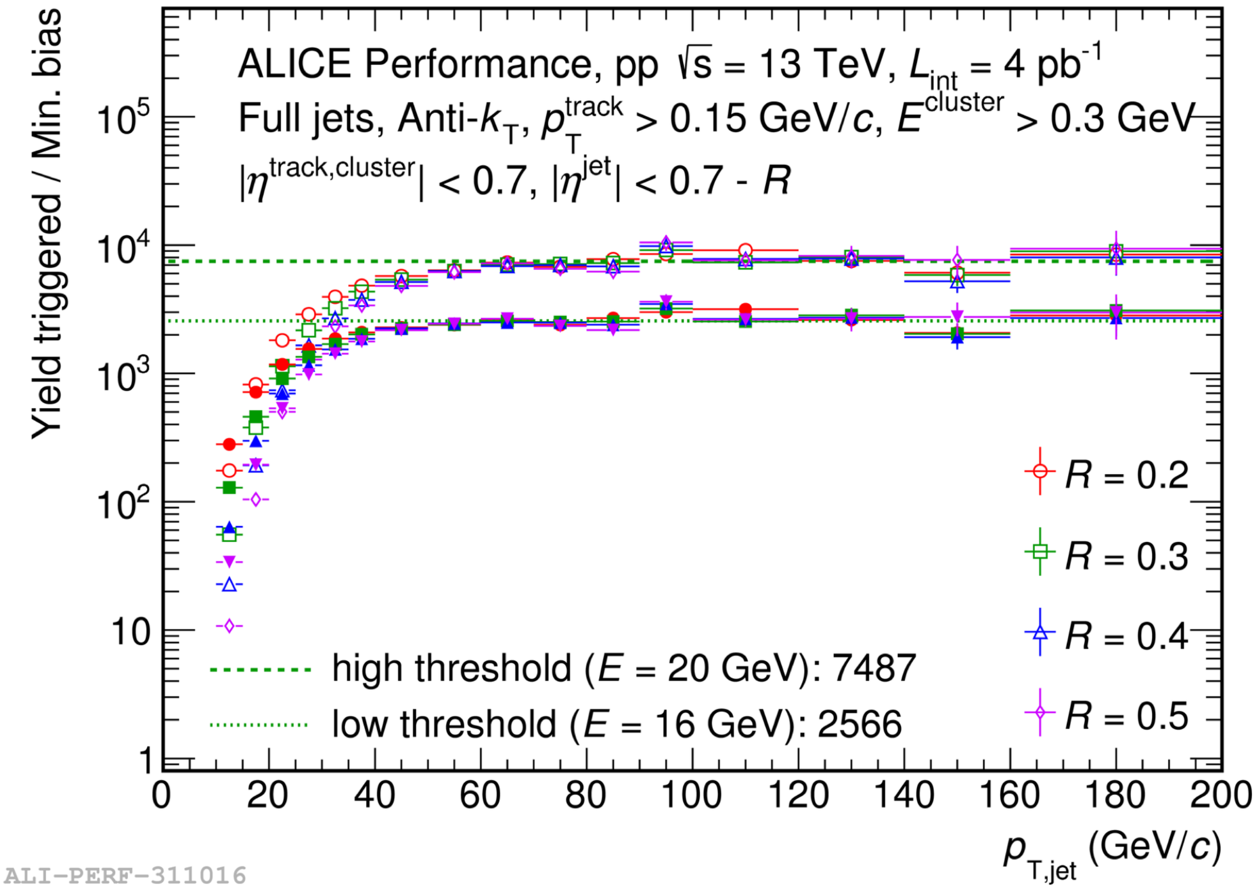


Dataset:
- Min. bias: $\int \mathcal{L}dt$ = 11.5 nb^{-1} collected in 2016 + 2017
- Triggered: $\int \mathcal{L}dt$ = 4 pb^{-1} collected in 2017

Jet reconstruction:
- Anti-k_T algorithm, E-scheme
- R=0.2 – R=0.5
- 30 GeV/c < p_T < 200 GeV/c

Performance of the jet trigger

Based on neutral energy in EMCal in a jet patch corresponding to R~0.3

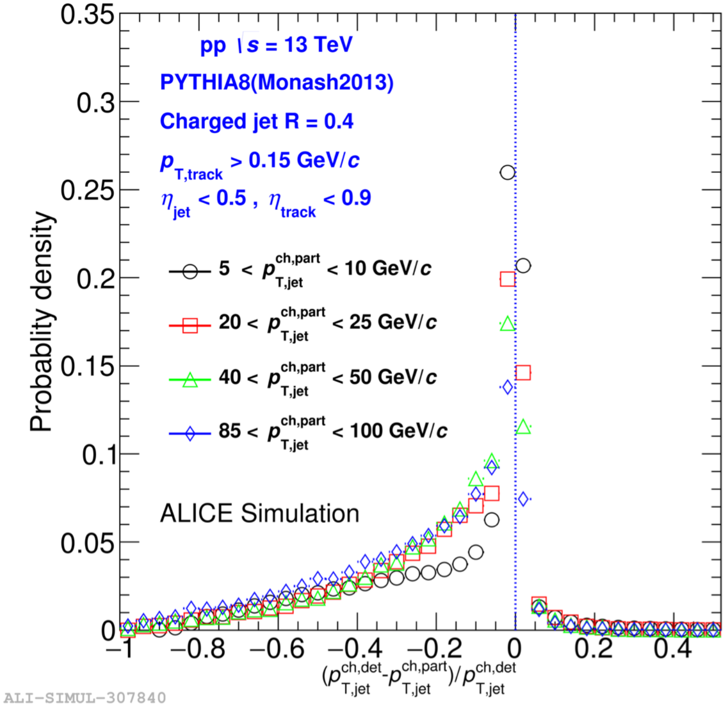


No trigger bias:

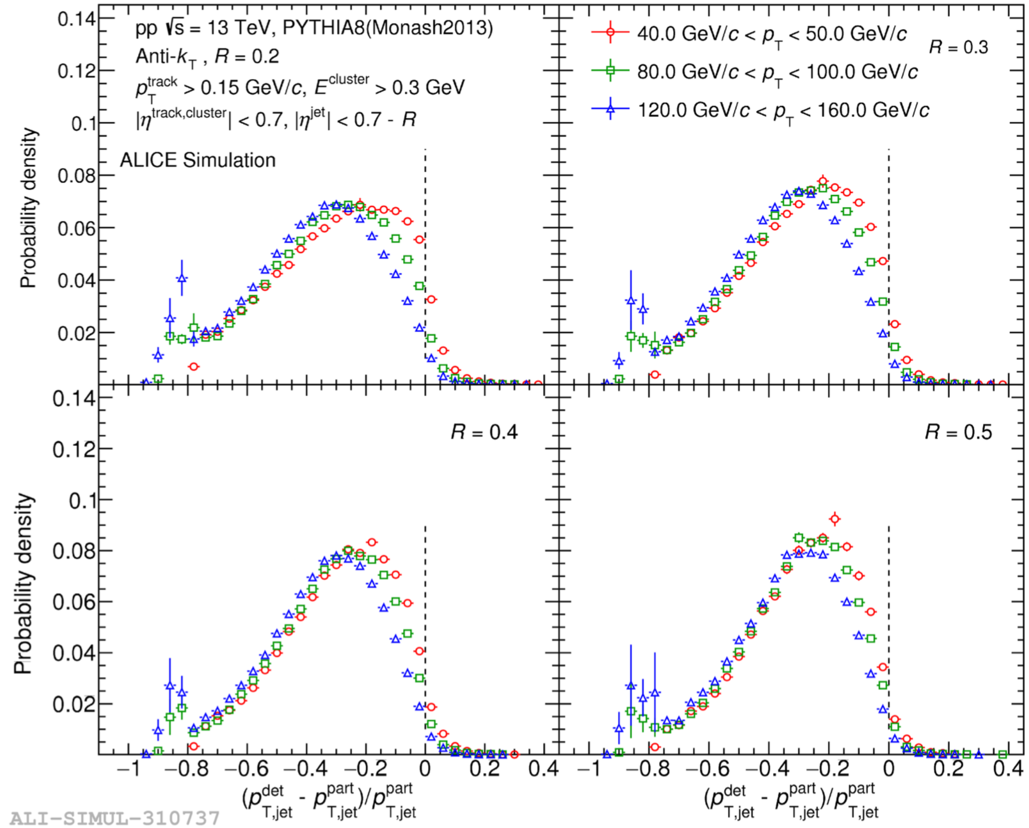
- Low threshold: 60 GeV/c
- High threshold: 80 GeV/c

Bias free region region defines p_T-ranges where triggers contribute to substructure measurements

Charged jets



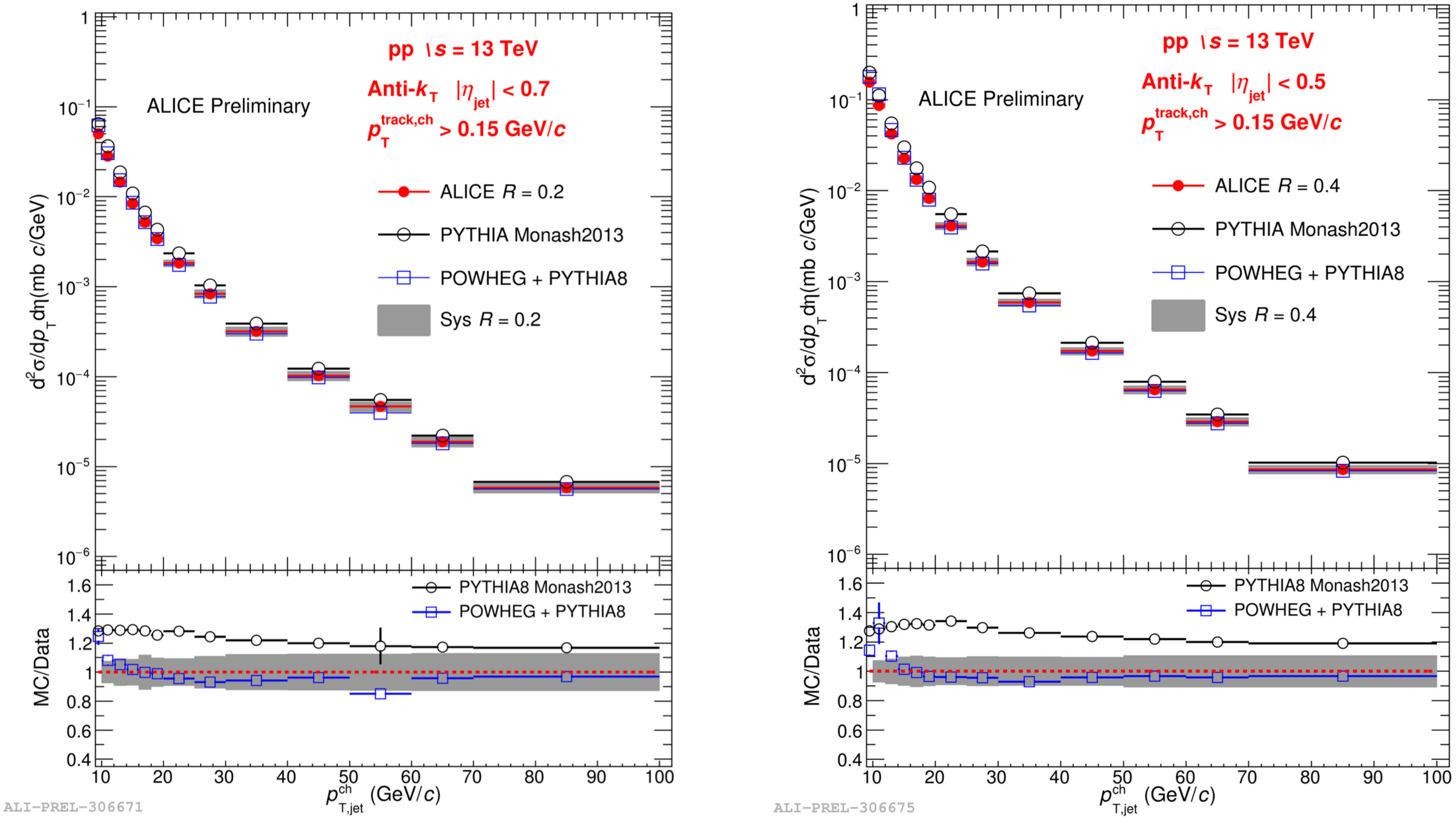
Full jets



Charged jets: only including charged constituents at particle level

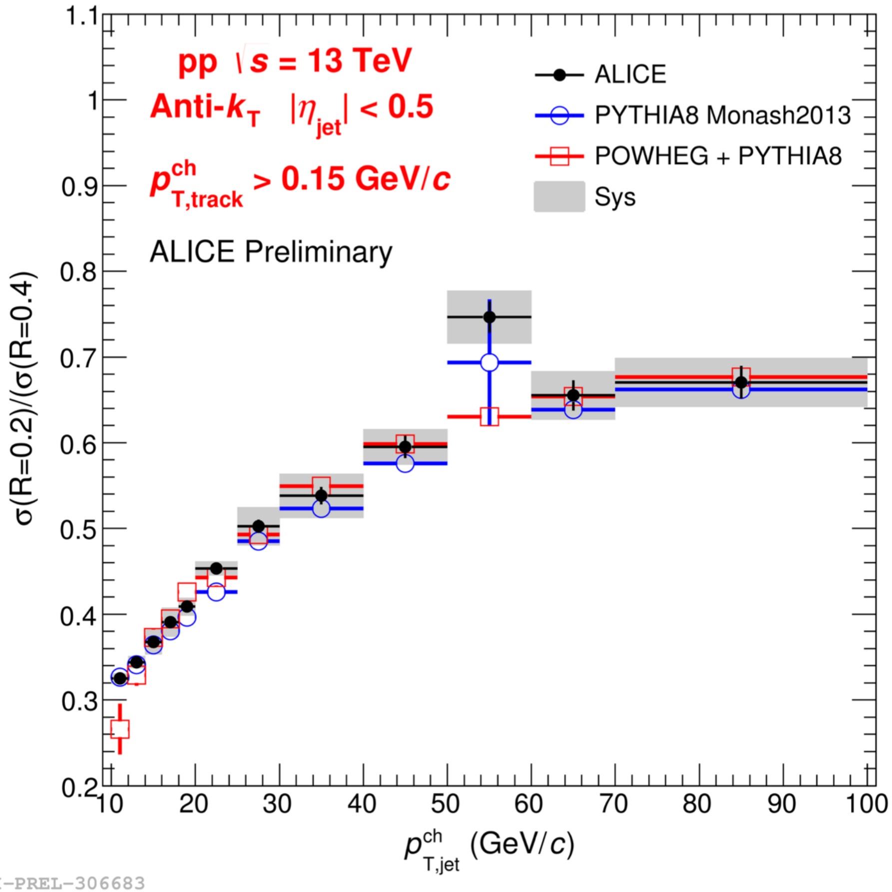
Neutral jets: Full jet energy at particle level

Differential jet cross section in pp collisions at √s =13 TeV for track-based jets



Good agreement with generators at low-p_T

Ratios of cross sections for different R

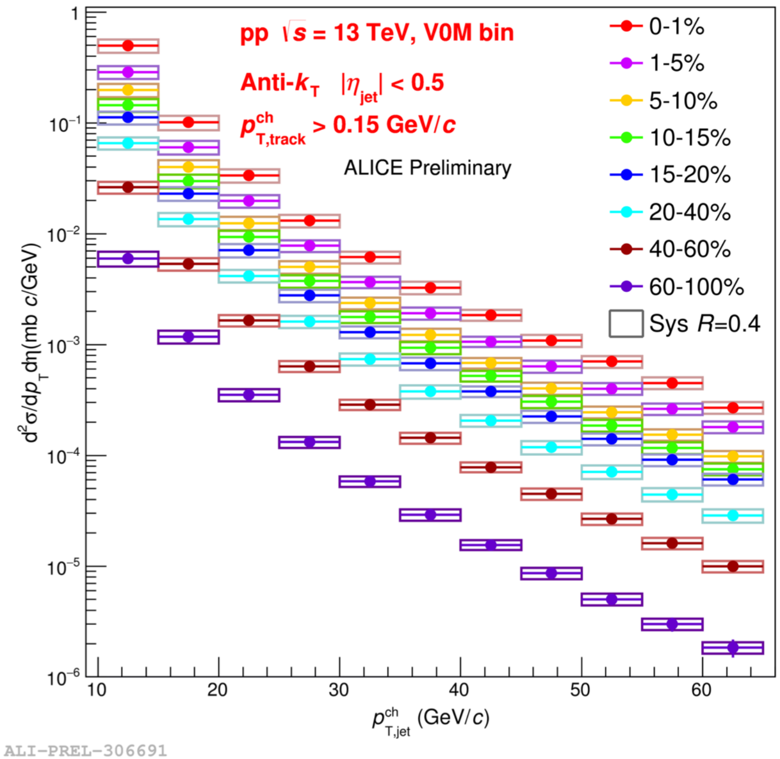


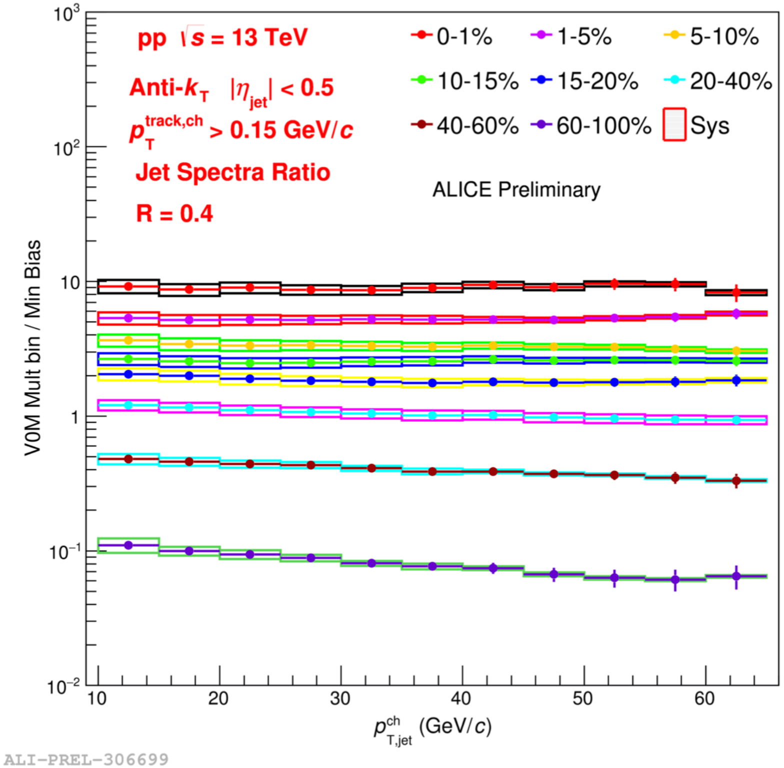
Ratios of jet cross sections with different *R* are sensitive to intra-jet broadening

In good agreement with PYTHIA and POWHEG

Charged jet production as function of the charged particle multiplicity

Study correlation between hard interaction and event activity

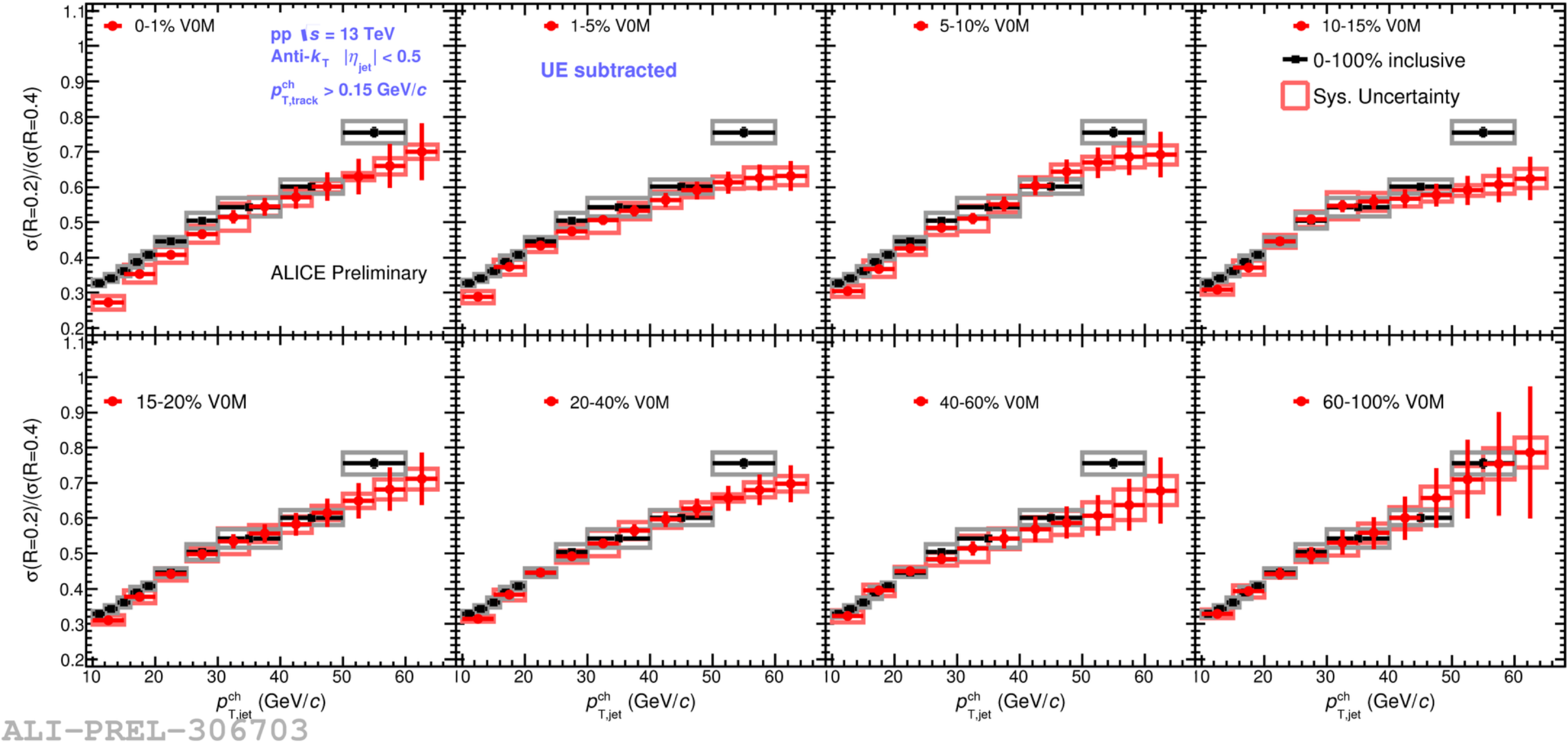




Weak p_T-dependence in different multiplicity bins

Y. Hou, Poster session

Charged jets production as function of the multiplicity



Weak multiplicity dependence in ratio of the jet spectra

Similar trends observed with PYTHIA

Y. Hou, Poster session

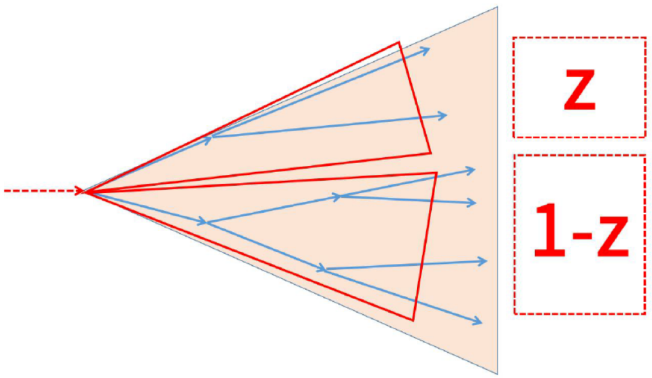
Grooming via the SoftDrop algorithm

Extract the hard components of a jet

- Recursively removing large-angle soft radiation
- Method:
  - Recluster jet (with Cambridge/Aachen algorithm)
  - Decluster tree
  - Remove softer branch until SoftDrop condition is fulfilled

$$z_g = \frac{\min(p_{T1}, p_{T2})}{p_{T1} + p_{T2}} > z_{cut}$$

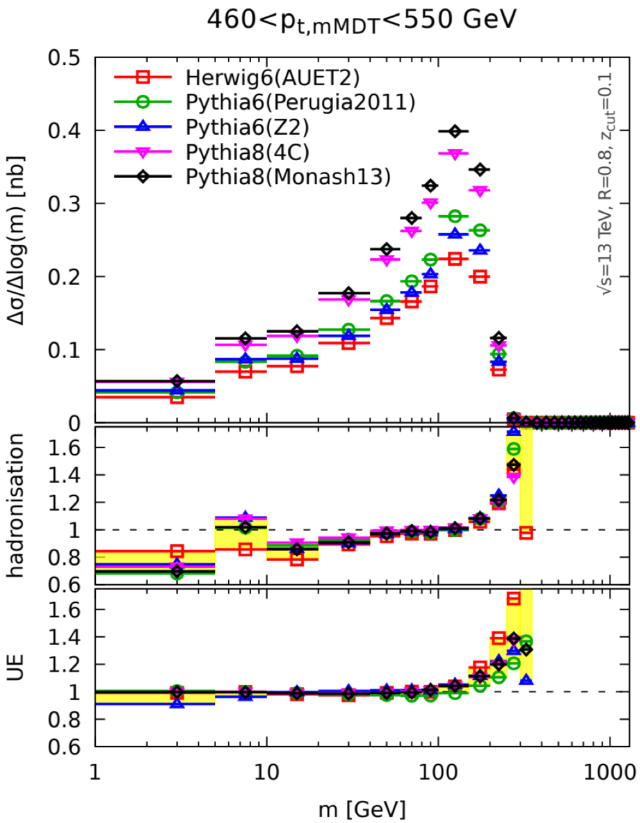
  - Grooming controlled by z_{cut} and β



M.Dasgupta, A. Fregoso, S. Marzani, G. P. Salam JHEP09 (2013) 029,
A. Larkoski, S. Marzani, G. Soyez, J. Thaler JHEP 1405 (2014) 146

Expectations from theory

Related example: groomed mass



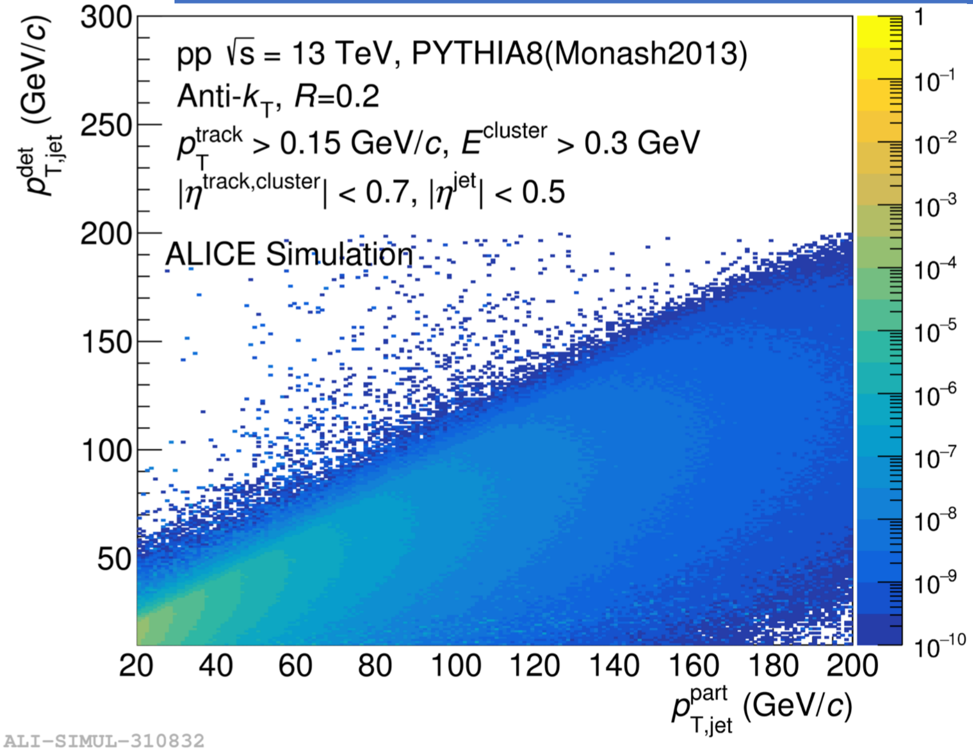
S. Marzani, L. Schunk, G. Soyez JHEP 07 (2017) 132

- z_g directly related to the splitting function
- p_T-depence:
  ⇒ Not expected (directly connected to QCD z kernel)
- R-dependence
  ⇒ Different perturbative / non-perturbative effects dominate for different R

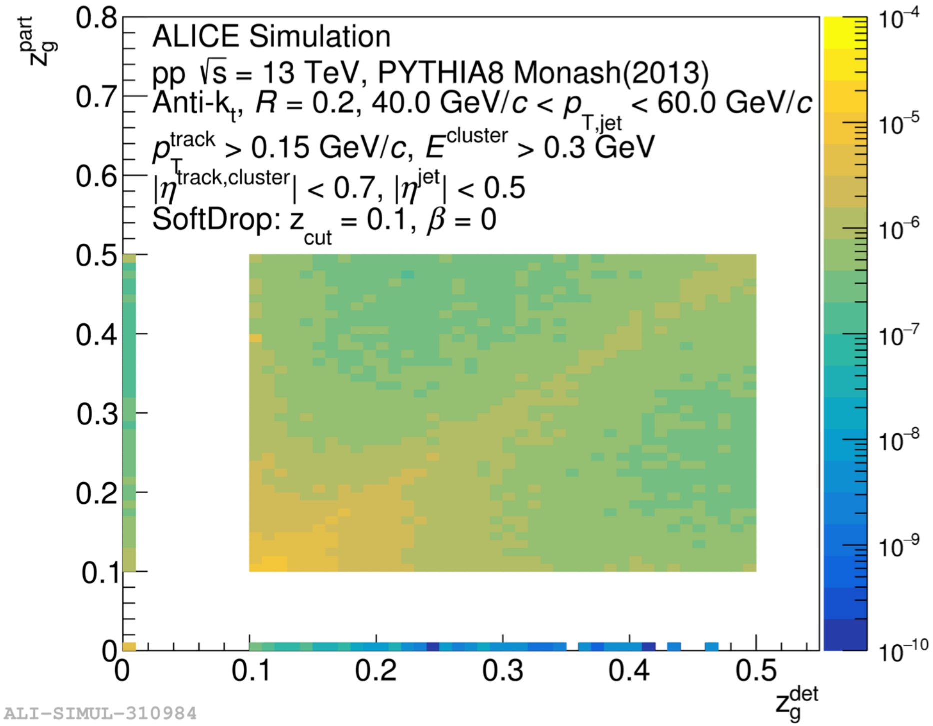
Perturbative Radiation	$\delta p_t \sim \ln(R)$
Hadronisation	$\delta p_t \sim -\frac{1}{R}$

Substructure allows to isolate ingredients of the theoretical description of jet production

Instrumental response of the z_g shape

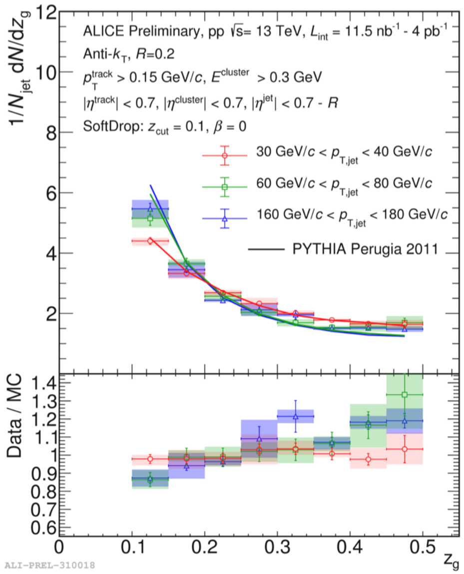


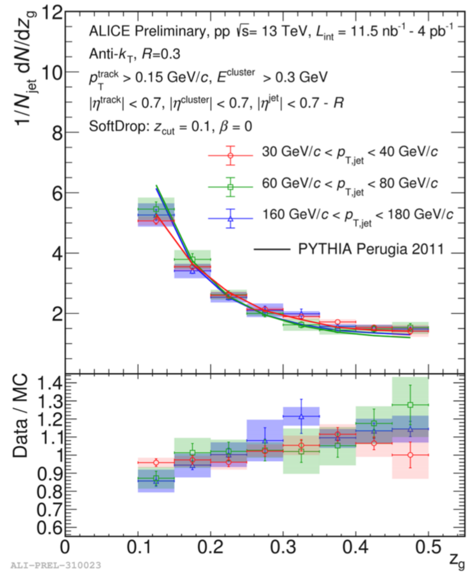
z_g response has wing / off-diagonal entries

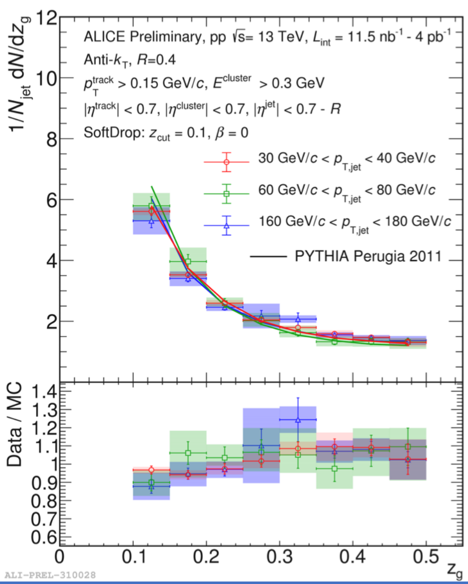


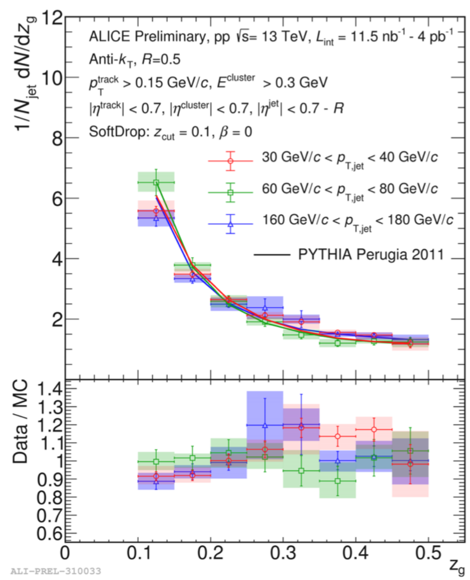
Bayesian unfolding in 2D used to correct back to particle level

Groomed momentum fraction vs p_T









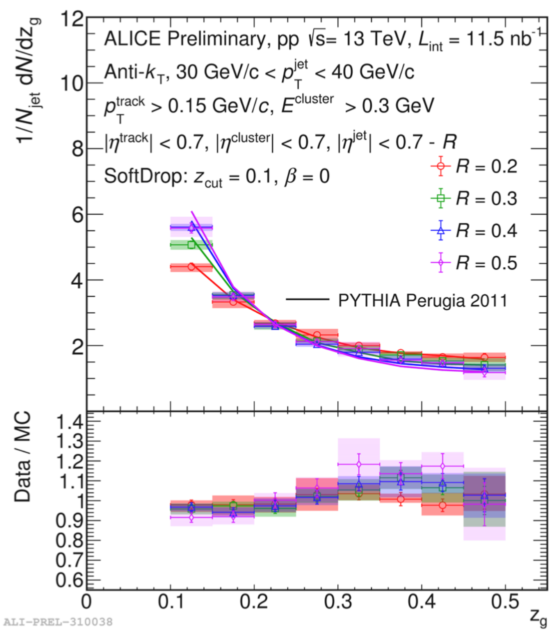
- p_T-dependence for smal radii
  - Trend to larger z_g at low p_T and towards smaller z_g at high-p_T
- No pt dependence or larger jet radii
- Generators reproduce p_T-dependence well

No underlying event subtraction applied

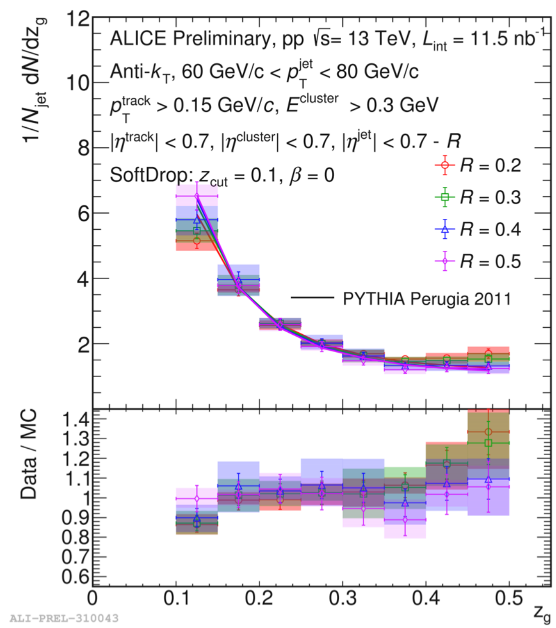
- Grooming already removes the soft component
- No underlying event subtraction in PYTHIA as well

Groomed momentum fraction vs *R*

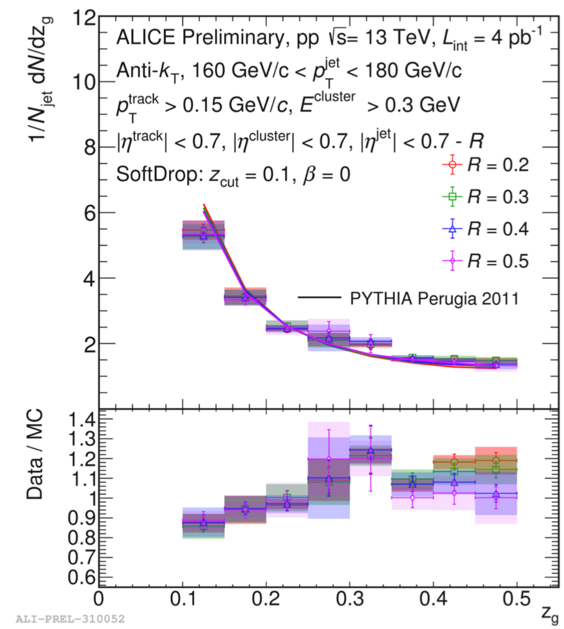
30 GeV/*c* < p_T < 40 GeV/*c*



60 GeV/*c* < p_T < 80 GeV/*c*



160 GeV/*c* < p_T < 180 GeV/*c*



Low p_T: Shape different for small and large jet radii
- Trend towards **more asymmetric splitting for larger R**
- At the same p_T larger jets capture more soft large-angle radiation
- Sensitivity to non-perturbative effects / underlying event

High p_T: z_g independent of *R*
- Dominant part of the jet energy in core, small influence of large angle radiation

PYTHIA reproduces the trend at low p_T very well

Conclusions and outlook

- Measurement of jet substructure in a wide range of jet radii and jet p_T
- Ratios of cross sections of various jet radii in good agreement with PYTHIA and PYTHIA+POWHEG
- No dependence of z_g on the jet p_t except in the lowest p_T-bins
- Weak dependence of charged jet production on the charged particle multiplicity in pp collisions
- Outlook: Measurement to be extended with more shapes (Rg, number of dropped branchs, ...)